TIME AND INTENSITY OF SETTING OF THE OYSTER, CRASSOSTREA VIRGINICA, IN LONG ISLAND SOUND

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The literature on the propagation of oysters is extensive. It consists of hundreds of articles in numerous publications, many of which are obscure State and local reports of comparatively limited circulation. Articles on spawning and setting of the American or Eastern oyster, *Crassostrea virginica* Gmelin (until recently known as *Ostrea virginica*), constitute by far the larger portion of the literature dealing with this aspect of oyster biology.

It would be impossible to offer here a comprehensive review of this voluminous literature. Furthermore, such review is unnecessary because the majority of the articles on the propagation of oysters have been included by Baughman (1948) in his annotated bibliography. Korringa (1952) commented on many articles that appeared after Baughman's bibliography was published, and recently Galtsoff (1964) offered another comprehensive résumé. Thus, with the exception of a relatively few papers published during the last year or two, I shall mention principally the articles directly pertaining to the propagation of oysters in New England waters, especially in Long Island Sound, where most of the work reported in the present paper was done.

A general description of the Long Island Sound region has been given in several previous papers (Prytherch, 1929; Loosanoff and Engle, 1940; Loosanoff, 1964). It will therefore be sufficient merely to point out here that the oyster setting grounds in Long Island Sound are confined principally to the Connecticut side, where the outline of its shore is irregular, composed of numerous harbors, bays, and other indentations. Many streams and rivers enter the Sound on the Connecticut shore; some form extensive estuaries, as that of the Housatonic River.

Long Island Sound has been an extremely important area since the cultivation of oysters was begun in the United States. One of the best historical reviews of the Connecticut oyster fisheries was given by Sweet (1941). As early as 1845, seed oysters collected from natural beds were planted in other areas and, eventually, plantings of large quantities of seed oysters were made in deeper waters of Long Island Sound on grounds which normally did not produce these mollusks. The planting of old shells to catch oyster set was initiated along the Connecticut shore of Long Island Sound in 1847, 8 years before the famous French oyster expert, Coste, began his extensive and successful experiments on cultivation of oysters in France.

During the prosperous era of the Connecticut oyster industry, the cultivated beds extended in a strip three to five miles wide, from Stony Creek to Stamford, a

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distance of about 40 miles. At one time nearly 50,000 acres of bottom were under cultivation.

According to the records of many Connecticut oyster companies, only a few of which still exist, and reports of the Connecticut Shellfish Commission, heavy oyster sets were routine during the last quarter of the 19th century (Loosanoff and Engle, 1940). Between 1904 and 1925, however, a period of 22 years, not a single heavy set occurred in the Sound. Since 1925, good sets have occurred in Long Island Sound in only a few years, namely, 1930, 1939, 1940, 1941, 1944, 1945, 1955, and 1958. The other years have been complete failures or so-called marginal years during which either the set was general but too light to be commercially important, or the set was good in some sections of the Sound but failed in the major portion of the oyster-producing area.

The method which Connecticut oyster farmers use to obtain new oyster generations consists of spreading on the oyster beds each summer large quantities of old shells to which metamorphosing larvae can attach. In some years, when the industry experienced periods of prosperity, over a million bushels of oyster shells were planted in areas where setting of oysters could be expected. Plantings extended from the mean low-water mark to a depth of 40 feet or sometimes deeper. When setting failed, the planting of shells resulted in heavy monetary losses.

Because of infrequent and generally light sets, the oyster industry began to feel the lack of seed oysters and looked for explanations for the failure of oysters to set in Connecticut waters. Furthermore, since the oystermen had no knowledge as to when the heaviest periods of setting might occur, they often planted shells either too early or too late to obtain the best sets, even during good years. This situation existed in the early 1920's, when the U. S. Bureau of Fisheries detailed an investigator to Connecticut to work on the problem of lack of set (Prytherch, 1929). The original and primary purpose of these studies was to determine, if possible, the presence of clear-cut relationships between successful propagation of oysters and the conditions of their environment and, on this basis, to develop methods for predicting well in advance the time and intensity of setting of oysters.

It was believed originally that not more than 5 to 7 years would be required to gather the necessary data. For several reasons, however, these investigations had to be continued over a much longer period; eventually they covered more than a quarter of a century. Within a few years after beginning these observations it was discovered that variations in time and intensity of oyster setting were not as simple to explain and predict as had been first thought (Prytherch, 1929). Moreover, in the early 1930's I began to issue special bulletins for the information of the oyster growers on gonad development, spawning and setting of oysters, and survival of oyster set. These bulletins became of considerable interest and value to the oystermen and they insisted on a continuation of this work. During these studies over 60 articles were published on various aspects of biology of oysters, several of which are referred to in this paper. Many others on improvement of methods of oyster cultivation and control of their enemies were also written. Some of the latter, for example, the observations on spawning and setting of the common starfish, *Asterias forbesi*, of Long Island Sound, have been published (Loosanoff, 1964).

All of the results of these investigations cannot be conveniently discussed in a relatively short paper. The present article, therefore, is devoted to a description

of the chronological aspects of spawning and setting of oysters in Long Island Sound and is to be followed by two more on the numerous biological and ecological variables that affect the propagation of oysters. To be included in the later articles are statistical analyses of the data to evaluate their relative importance and their possible value in predicting some important aspects of spawning and setting.

The data in this article are based upon observations made at many stations, but chiefly those at a depth of 30 feet or less. Statistical analyses already reported (Loosanoff, 1964) have shown that conditions at stations located at 30 feet and less are representative for the entire Long Island Sound.

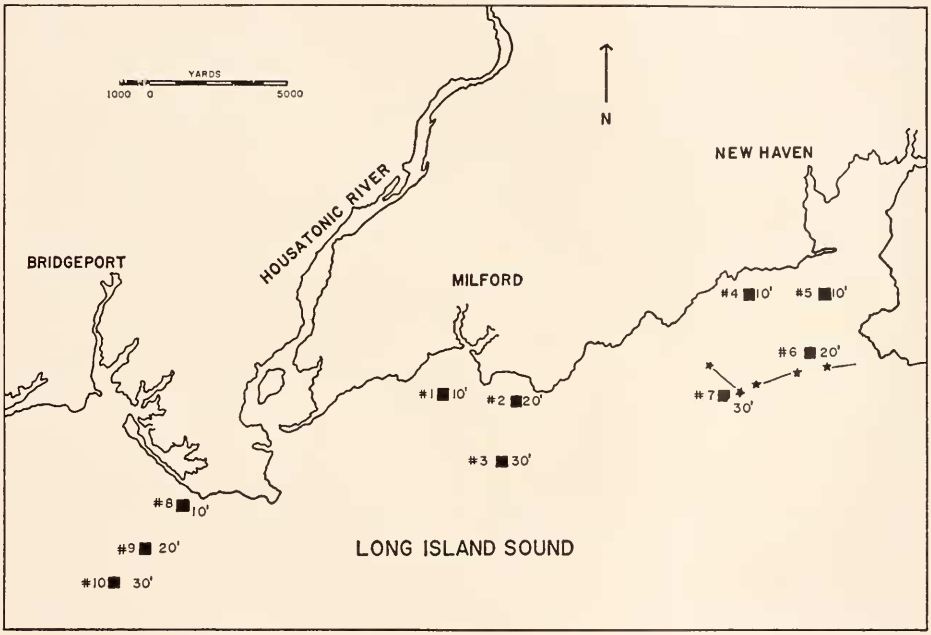

FIGURE 1. Location and depth of 10 stations established for observations on time and intensity of setting of oysters in Long Island Sound, 1944–61.

METHODS

These studies were conducted from 1937 to 1961 at the U. S. Bureau of Commercial Fisheries Biological Laboratory, Milford, Connecticut. In 1937–43 the chain of stations sometimes extended from Thimble Islands, east of Branford, to Westport (Loosanoff and Engle, 1940). In 1944–61 (except 1957, when only three stations were maintained), observations were carried on at the same 10 stations, located between New Haven and Bridgeport (Fig. 1). The studies dealt with various aspects of the propagation of oysters, including gonad development, discharge of spawn, occurrence and distribution of larvae, and the beginning and end of setting of larvae. The variations in time and intensity of setting throughout each summer constituted part of this investigation. Included also were systematic

studies of environmental factors, among them changes in temperature, salinity, and pH of the water, amount of precipitation, river discharge, hours of sunshine, direction and velocity of winds.

The time and intensity of setting in different areas were determined by examining special collectors placed at each station. These devices (Fig. 2), which were wire bags filled with clean oyster shells, were first suggested in 1925 by Captain E. C. Wheeler of the Connecticut Oyster Farms Company. We have used this type of collector successfully in Virginia (Loosanoff, 1932), and later throughout the entire period of our studies in Connecticut.

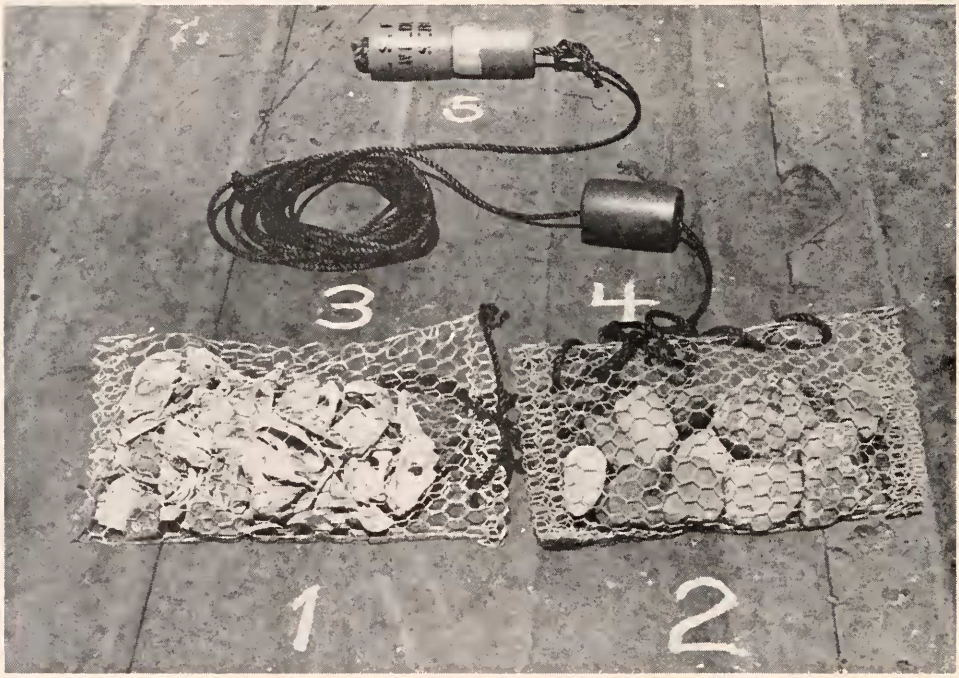

FIGURE 2. Type of collectors used for observations on setting of oysters in Long Island Sound. Description in text.

The wire-bag collector (Fig. 2-1) contained about 35 or 40 oyster shells of more or less uniform size. Two bags were used at each station. Another bag (Fig. 2-2), filled with small rocks, served as an anchor. A treated rope (Fig. 2-3) was run from the shell bags to the anchor bag, then to the auxiliary buoy (Fig. 2-4), which supported the middle portion of the rope, especially after it became waterlogged. A brightly colored buoy (Fig. 2-5) indicated the location of the collector.

Collectors were changed twice a week. The bags were brought into the laboratory and the shells examined within a few hours. The men counting the set were trained to distinguish oysters of different ages, from the time of attachment until they were about four days old. The set was counted on the inside surfaces of 20

shells taken at random from each collector and the results were later expressed as the number of oyster spat per 100 shell surfaces. This method is identical to the one used in studies of variations in time and intensity of starfish setting in Long Island Sound (Loosanoff, 1964).

Since two collecting bags were used to gather the data for each station and for each collection date, a pair of values was always available. It was possible, then, to correlate these values and to obtain an estimate of the reliability of the data. This analysis was made for two years, 1944 and 1955, which were chosen because the set of oysters was fairly heavy both years and because both years were characterized by considerable heterogeneity among the various stations. The only collection dates included in the analysis were those on which the set was appreciable, 10 or more oyster set in at least one of the 20 bags. For each date a correlation was computed between oyster set in bag A and oyster set in bag B from each of the 10 stations. These correlations ranged from 0.65 to 0.98 in 1944 and from 0.66 to 0.98 in 1955; the agreement between the two samples taken at the same time and place was excellent.

Observations

Systematic observations on gonad development and spawning of the oysters of Long Island Sound were conducted every summer from 1937 to 1956, a period of 20 years. A detailed description of gonad development has recently been given (Loosanoff, 1965).

In general, the spawning period in Long Island Sound waters lasts 2½ to 3 months; this time is considerably shorter than in warmer southern waters where, in some areas, spawning may continue throughout the greater part of the year (Hopkins, 1954). Prytherch (1929) offered a method which, in his opinion, was reliable enough to predict the start of spawning of oysters in Long Island Sound one month in advance. According to him a prediction could be made on the basis of several factors, of which water temperature from April to July was the most important. The strange part of Prytherch's proposal was the statement that the prediction could be made between July 1 and July 10 of each year, a period which obviously is too late for such a prediction because the spawning in Long Island Sound normally starts between June 26 and July 3 (Loosanoff, 1965).

Observations on occurrence and distribution of oyster larvae in the inshore waters of Long Island Sound constituted an integral part of this study. Unfortunately, they could not be carried out over as broad a scope as was desired, because of scarcity of personnel. Nevertheless, even these limited observations provided rich information of considerable biological interest.

Plankton samples for determination of the number of oyster larvae were collected by filtering known volumes of sea water through plankton nets. In our earlier studies, 50-gallon samples were pumped from near the surface and bottom, but because oyster larvae were rather uncommon, the volume of samples was later increased to 100 and eventually to 200 gallons. To facilitate the collection of such large samples the water was filtered through two nets: first, a coarser one made of #10 plankton netting, which retained most of the zooplankton, including larger bivalve larvae, and then through a #20, net, which retained the smaller

larvae. The use of a #10 net prevented the clogging of the finer #20 mesh. This method is still used at Milford.

Several students of oyster propagation (Baughman, 1948) have made observations on the distribution of oyster larvae in Long Island Sound. In earlier articles, including Loosanoff and Engle (1940), many figures were based on the counts of younger, so-called straight-hinge stages of larvae. Since oyster larvae at that stage have an appearance almost identical to larvae of some other species, for example, those of *Mulinia lateralis,* these early counts were not wholly reliable.

Similar errors cannot be made, however, in identification of older oyster larvae, measuring 100 microns or more. The oyster larvae of this size are unique in appearance; no larvae of other bivalves of Long Island Sound can be mistaken for them, with the possible exception of larvae of *Teredo.* Even larvae of *Teredo* and oysters are sufficiently different to be distinguished by an experienced worker.

Since the studies on distribution and occurrence of oyster larvae covered more than 25 years, they are too extensive to be discussed in detail here. Only a brief summary of this subject is offered, therefore. In general, oyster larvae in Long Island Sound, especially those of advanced stages, were never numerous; they were unevenly distributed over the oyster-producing areas, and their appearance or disappearance did not follow any definite pattern.

Frequently the samples of larvae were composed entirely of individuals of advanced stage of approximately the same size. This observation was interpreted to mean that the larvae probably originated in an area other than the place they were collected and were brought along as advanced larvae with masses of water which retained their identity during the entire period of larval development.

Our efforts to correlate the numbers of larvae with some obvious factors of their environment were mostly unsuccessful. The literature contains several referances (including that of Nelson, 1925) in which unsuccessful setting of oysters is attributed to ctenophores that have, presumably, eaten the majority of the larvae originally present. During the studies we had many opportunities to test this theory. We found, however, that no clear-cut relation existed between the numbers of ctenophores and the failure of oyster set. For example, ctenophores were so numerous in the Bridgeport-New Haven area between July 28 and August 12, 1944, that swimming was discontinued at many beaches, and collection of plankton samples was practically impossible even though several straining devices were used to prevent the ctenophores from entering the nets. Yet, this period produced one of the heaviest oyster settings in the history of Connecticut oyster farming.

Neither could the numbers of larvae be correlated with the numbers of parent oysters living in Long Island Sound. For example, in 1937, when more than a million bushels of adult oysters were growing in the Sound, many plankton samples taken in the middle of summer contained no oyster larvae (Loosanoff and Engle, 1940). On the other hand, in 1958, when the adult oyster population was extremely small, oyster larvae, especially those in advanced stages, were numerous, sometimes as common as three mature larvae per gallon of water.

Dead or dying bivalve larvae were found in our samples during some summers. One such observation was made in 1959 at Stations 2 and 5 in New Haven Harbor. Samples collected on August 20 contained many living larvae that

appeared abnormal. A few days later, on August 24 and especially August 31, many dead or dying larvae were taken.

Sufficient evidence is available to suggest that the absence or disappearance of the larvae from the waters of Long Island Sound may often be due to the plankton blooms that occur in this area in the summer. These blooms probably produce large quantities of external metabolites which are detrimental to larvae. It has been shown experimentally at our laboratory that a dense bloom of dinoflagellates causes abnormal development of eggs and larvae of the clam, *Mercenaria mercenaria,* and the oyster (Davis and Chanley, 1956). Even when eggs of oysters were placed in water from which the dinoflagellates were removed by a Millipore filter,

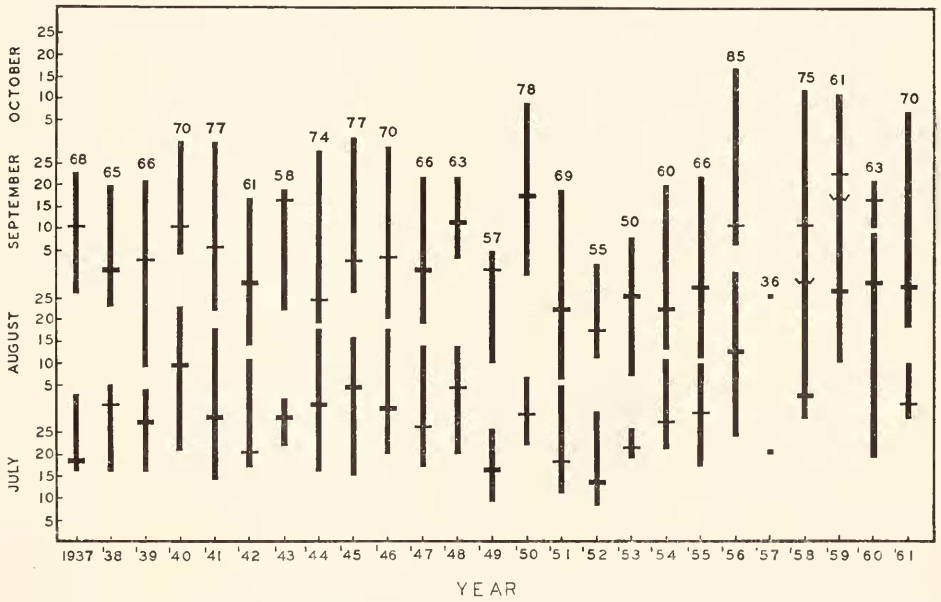

FIGURE 3. Beginning, end, and extent of setting period of oysters in different years in Long Island Sound, 1937–61. Cross-bars indicate the peaks of first and second waves of setting, the broader bars indicating the peaks of the heavier waves. Figures at top of each bar show number of days in setting period of each year.

the development of the eggs and larvae was still abnormal. It is also possible that during the periods of heavy blooms of dinoflagellates, such as *Prorocentrum triangulatum,* some nannoplanktonic forms, which constitute the food of oyster larvae, disappear and, as a result, the larvae may starve or grow slowly and be more susceptible to diseases.

The latest date at which mature larvae were found in our samples was October 8 (1959) when several were taken at Station 2, Milford Harbor, and 17 immature larvae were collected at Station 10 in Bridgeport Harbor.

In general, the length of the setting period of *C. virginica* increases from north to south. In Long Island Sound, as is shown later, this period extends from approximately the middle of July until the end of September or even early October.

TABLE I

Numbers of oyster set on 100 shell-surfaces, recorded semi-weekly at stations at 10 different depths off Stratford Point, Long Island Sound, 1939

Station number	1	2	3	4	5	6	7	8	9	10
Depth in feet	0	5	10	20	30	40	50	60	70	100
Date	Numbers of oyster set									
July 13	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0
20	120	20	20	60	60	0	10	0	0	0
24	590	1030	960	630	290	160	30	50	0	0
27	21560	26560	9980	13690	29980	9630	1420	370	20	10
31	6760	14340	27260	30430	21830	10040	1100	840	110	160
Aug. 3	310	570	440	310	140	0	40	20	10	0
7	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0
21	10	10	0	10	0	0	0	0	0	0
24	0	0	0	0	10	0	0	0	0	0
28	0	50	30	10	30	0	30	0	0	0
Sept. 1	0	0	0	20	20	10	0	0	0	0
4	20	20	40	190	480	10	30	10	0	0
7	100	60	40	200	200	30	0	0	0	0
11	40	30	10	40	70	40	0	0	0	0
14	0	30	30	10	0	0	10	0	0	0
19	10	0	10	20	0	0	0	0	0	0
21	10	10	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0
Station total	29530	42730	38820	45620	53120	19920	2670	1290	140	170

In Chesapeake Bay it normally continues from the middle of June until the middle of October (Loosanoff, 1932; Beaven, 1954). In South Carolina, however, the season is considerably longer than at either of the northern points just mentioned; it extends from early May through a large part of October (McNulty, 1953). Finally, according to Hopkins (1954) larvae of *C. virginica* set from April until November along the Gulf of Mexico coast. Obviously, the length of the setting period depends upon the temperature; it is longer where the climate is warmer.

During the 25 years of observations in Connecticut waters, the beginning of setting varied from year to year between July 9 and August 11 (Fig. 3). The mean date was July 20, and in the majority of years first setting took place between July 16 and 22. This finding supports broadly the formula which was offered earlier by Loosanoff and Nomejko (1951) who stated (p. 124) that "The beginning of oyster setting in Long Island Sound should be usually expected on July 19 ±4 days, regardless of lunar phases and of changes in hydrostatic pressure caused by changes in the tidal level." The exceptions to the rule were the years of 1949,

1951, and 1952, when setting began between July 9 and 12, and 1959, the only year when the beginning of setting was recorded later than the end of July (Fig. 3).

The observations on setting of oysters were made in some years from the intertidal zone to the depth of 100 feet (Table I). Setting was recorded at all depths but, as with starfish (Loosanoff, 1964), the duration of the setting at the deepest stations was shorter than at the shallower ones.

As a rule, setting began at all the stations in 30 feet of water or less within the

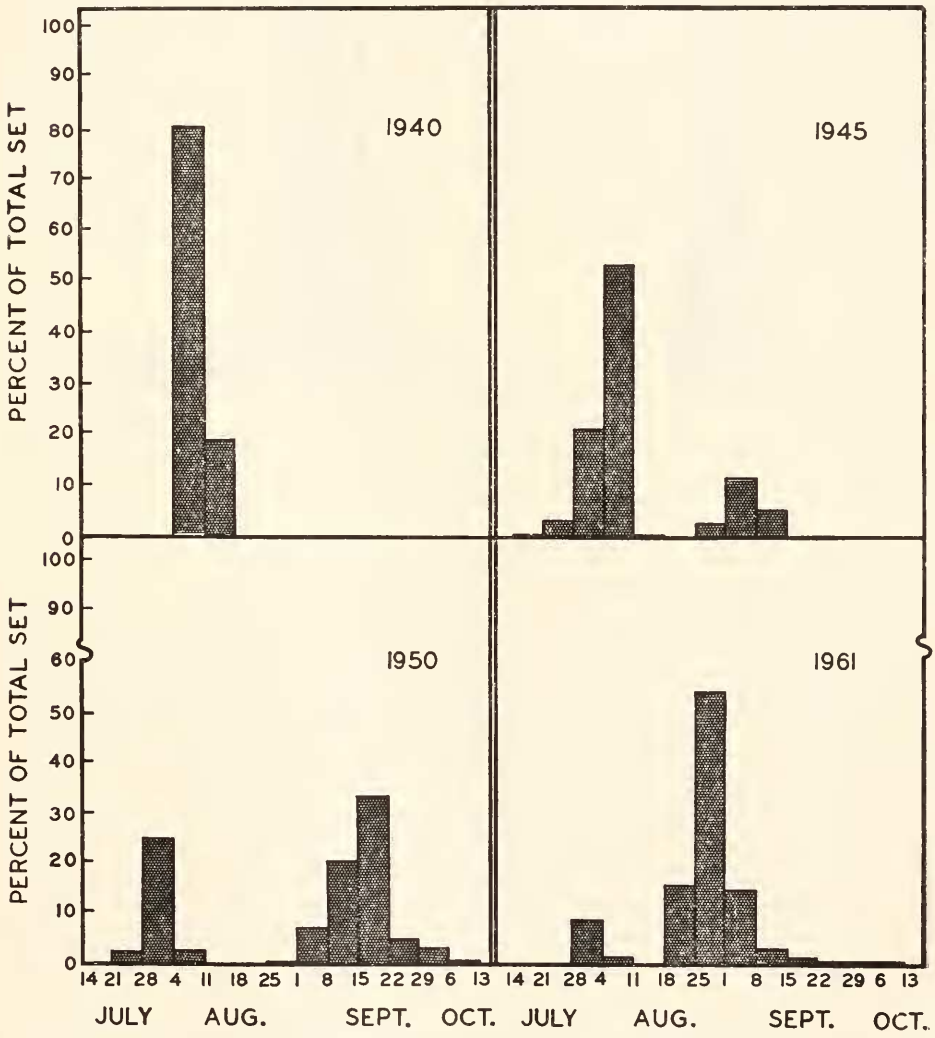

FIGURE 4. Variations in weekly intensity of oyster setting in different years. In 1940 99.76% of the entire set occurred within two weeks of the first wave, but in other years setting was more evenly distributed through the summer and two definite waves were distinguishable.

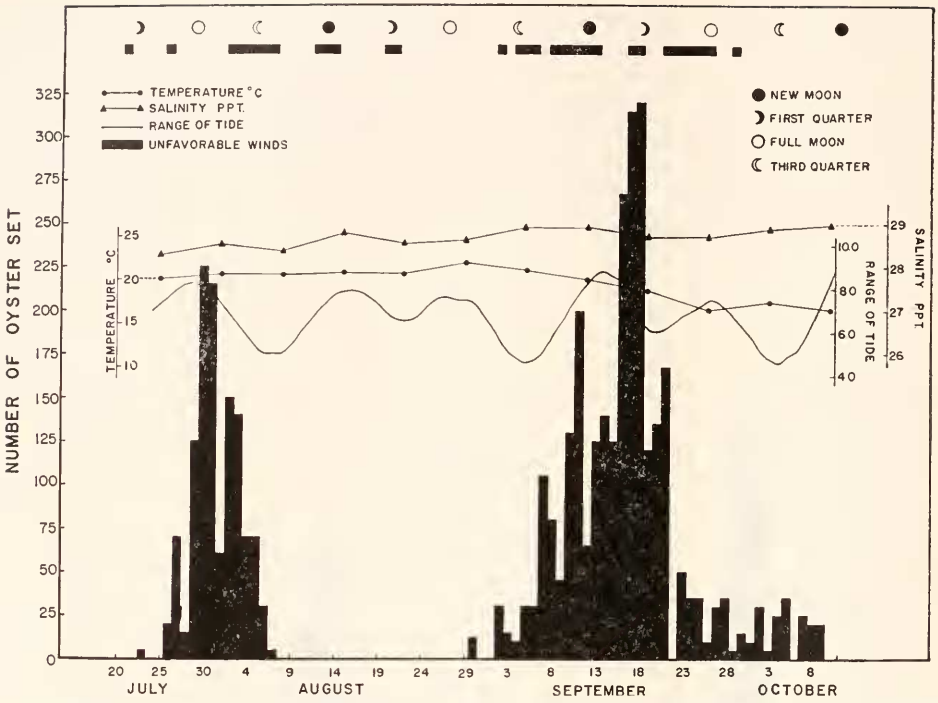

FIGURE 5. Average daily number of oyster set per station recorded in 100 oyster shell-surfaces in Long Island Sound, 1950. Two definite waves of setting, separated by a "dead period," can be seen. Some of the environmental conditions are also shown.

same 24-hour period. Even at stations located as deep as 50 or 60 feet, setting started at approximately the same time as at shallower stations.

As found in a parallel study on propagation of another invertebrate of Long Island Sound, the starfish (Loosanoff, 1964), the length of the setting period of oysters varied greatly in different years (Fig. 3). The shortest time between the beginning and end of setting was in 1957, only 36 days; while the setting period of the preceding year, 1956, extended for 85 days. In nine years the duration of setting was 70 days or longer, and the average length of the setting period was 65 days, or about two months.

The earliest date for the end of setting was August 26, 1957. This year, as mentioned earlier, had the shortest setting period. The latest date was October 17, 1956, when the period of setting was the longest within the period of our studies. The mean date for the end of setting was September 22. The difference between the earliest and the latest dates for the end of setting was 51 days, considerably larger than the difference of 34 days for the earliest and latest dates of the beginning of setting.

Although the average setting period of Long Island Sound oysters was about 65 days, the average length of the setting period of starfish during the same period was about 52 days. Thus, the lengths of the setting periods of these two invertebrates living under identical conditions do not differ radically.

The length of the setting period of oysters given here merely shows the number of days between the beginning and the end of setting. It does not mean that setting was continuous or of uniform intensity during this entire period. In reality, setting ceased for various (sometimes lengthy) periods almost every year. Such a "dead period," for example, occurred in 1950 when not a single oyster larva set on any of our collectors between August 7 and 30 (Fig. 5). This gap appeared even though the number of mature oysters in Long Island Sound then amounted to many millions. During most of this period the water of the Sound was colored somewhat pinkish by plankton blooms. A dinoflagellate, *Prorocentrum triangulatum,* was one of the common organisms present. In 1957 setting was recorded only on the first day and then 36 days later on the last day, while between these dates no setting occurred. The years 1958 and 1959 were exceptional because setting was continuous during practically the entire season (Fig. 3).

Further differences and peculiarities of setting in different years are illustrated in Figure 4. For example, the setting season extended for 70 days in 1940, but over 99% of the set was between August 5 and 18; the additional fraction of about 1% was spread so thinly through the remainder of the setting season that it cannot even be clearly shown in the illustration. Thus, during that year almost the

TABLE II

Average numbers of total oyster set per station per 100 shell-surfaces, and numbers of set recorded during each of the two waves, Long Island Sound, 1937–61

Year	Total set	Total 1st wave	Total 2d wave
1937	1640	1621	19
1938	1090	83	1007
1939	42623	42230	393
1940	42407	42378	29
1941	17225	15192	2033
1942	2138	71	2067
1943	72	57	15
1944	11147	10407	740
1945	4476	3530	946
1946	3267	1851	1416
1947	1136	438	698
1948	344	151	193
1949	739	730	9
1950	405	121	284
1951	1181	170	1011
1952	998	684	314
1953	2338	102	2236
1954	77	24	53
1955	10915	386	10529
1956	2289	1884	405
1957*	3	0	0
1958	15417	13903	1514
1959	2312	2250	62
1960	780	702	78
1961	234	23	211

* Only stations 1, 2, and 3, all in the Milford area, were maintained in 1957.

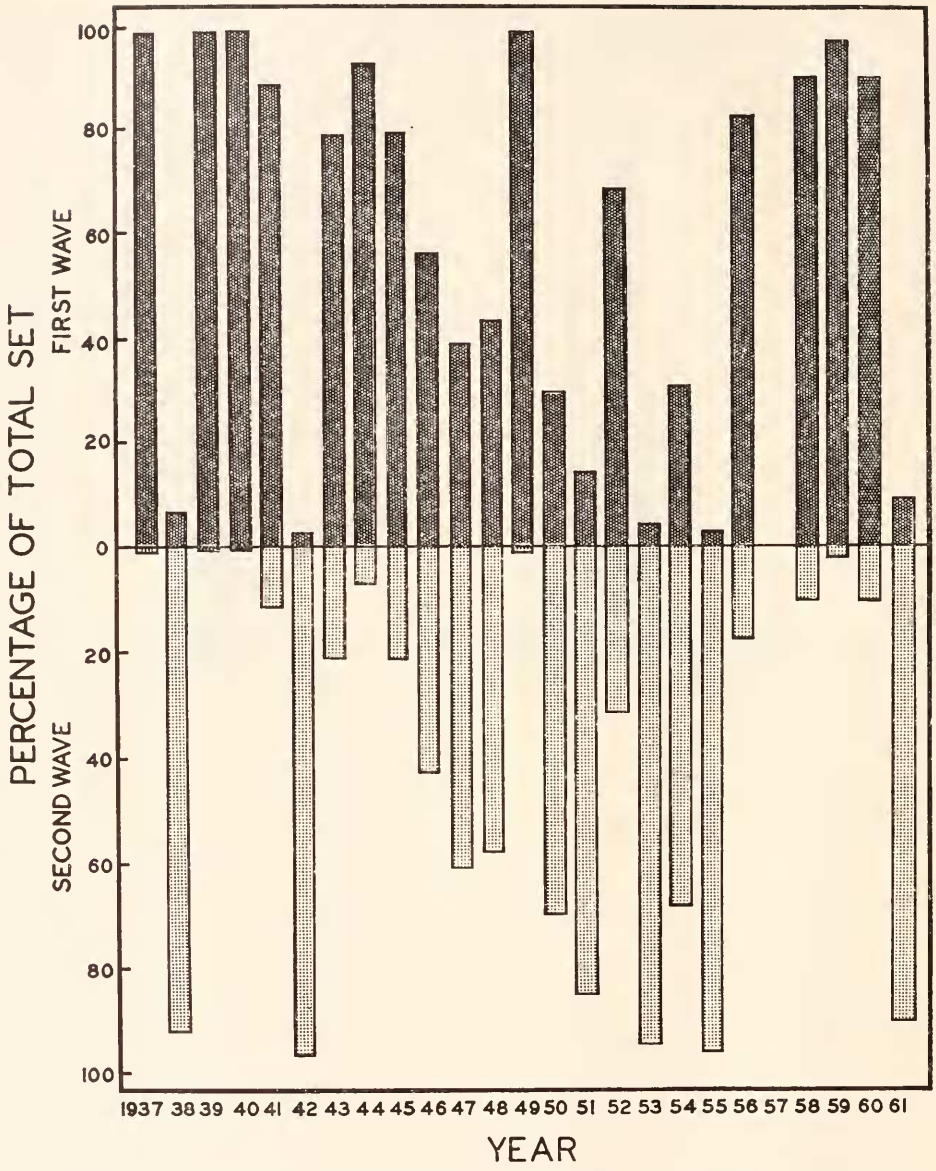

FIGURE 6. Percentage of total oyster set in each of the two waves during different summers, Long Island Sound, 1937–61.

entire setting occurred in a single wave of short duration. In 1945, however, setting took place in two waves, of which the first was the heavier. In contrast, during 1950 and 1961 the first wave of setting was the lighter of the two and the intensity of setting was much more evenly distributed throughout the setting period than in 1940 (Fig. 4).

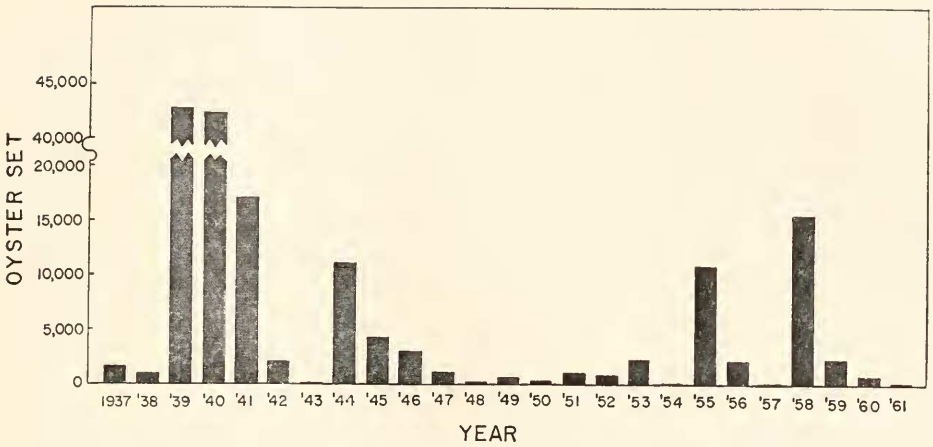

FIGURE 7. Average number of oyster set per station recorded in different years on 100 oyster shell-surfaces, Long Island Sound, 1937–61.

TABLE III

Average number of oyster set per station in different years on 100 oyster shell-surfaces, at stations located at 10-, 20-, and 30-foot depths, Long Island Sound, 1937–61

Year	Depth in feet		
	10	20	30
1937	2050	2175	695
1938	245	935	2090
1939	23945	45925	58000
1940	24635	54845	28200
1941	11454	21212	18515
1942	1000	2093	3345
1943	65	81	35
1944	24700	1775	2447
1945	6348	4649	1774
1946	1748	6508	2053
1947	1109	1467	842
1948	314	542	184
1949	783	585	833
1950	278	540	440
1951	848	707	2098
1952	1395	1283	183
1953	615	3028	3945
1954	74	95	63
1955	3660	7031	24473
1956	1641	1983	3457
1957*	5	5	0
1958	12977	32581	1505
1959	2216	3723	1030
1960	612	1376	406
1961	391	240	20

* Only stations 1, 2, and 3, all in the Milford area, were maintained in 1957.

Again we see a similarity in some aspects of setting of oysters and starfish of Long Island Sound because the latter also show considerable variation in intensity of setting during different summers. Sometimes the entire set may occur within a single week or 10 days, whereas in other years setting continues for a long time although the intensity may vary greatly from week to week (Loosanoff, 1964).

The beginning of the first wave of oyster setting varied from July 9 (1952) to August 11 (1959), and had a mean of approximately July 20 (Fig. 3). The earliest end of the first wave was July 21 (1957), a year of extremely poor setting, and the latest was September 17 (1959); the mean was approximately August 12. The date of the beginning of the second wave varied from August 7 (1951) to

TABLE IV

Rank-order of years in relation to the intensity of setting of oysters at stations of three different depths, Long Island Sound, 1937–61

Year	Rank-order of years at each depth (feet)				Year	Rank-order of years at each depth (feet)			
	10	20	30	All stations		10	20	30	All stations
1937	9	10	17	13	1950	21	21	18	20
1938	22	17	10	16	1951	15	18	9	14
1939	3	2	1	1	1952	12	16	21	17
1940	2	1	2	2	1953	17	9	5	9
1941	5	4	4	3	1954	23	23	22	23
1942	14	11	7	12	1955	7	5	3	6
1943	24	24	24	24	1956	11	12	6	11
1944	1	13	8	5	1957*	25	25	25	25
1945	6	7	12	7	1958	4	3	13	4
1946	10	6	11	8	1959	8	8	14	10
1947	13	14	15	15	1960	18	15	19	18
1948	20	20	20	21	1961	19	22	23	22
1949	16	19	16	19					

* Only stations 1, 2, and 3, all in the Milford area, were maintained in 1957.

September 18 (1959), and the average was August 23; the end of the second wave which, of course, was the end of the setting season, came between August 26 (1957) and October 17 (1956); the average was about September 23.

The peaks, or maxima, of the waves also varied considerably from year to year. Their approximate dates are indicated in Figure 3 by cross-bars. The peaks of the first wave came between July 14 (1952) and August 29 (1960); the approximate average was July 30. The second wave had peak dates from August 19 (1952) to September 23 (1959), and an average of September 4. The difference in days between the maxima of the two waves ranged from 19 days (1960) to 40 days (1943).

Neither the first nor the second wave of setting was consistently the predominant one. Table II, giving average numbers of total oyster set per station for the two waves in each year, shows that each wave was dominant in a number of years. In some years almost 100% of the annual set took place during the first wave, but in others most setting was later in the season, during the second wave (Fig. 6).

Within the 25-year period the first wave was the heavier in 15 years and the second in 10.

In most years the heavier of the two waves predominated decidedly. Nevertheless, there were few years when the percentage of total set during the season was more or less evenly divided between the two waves. The years 1946, 1947, and 1948, when about a 40:60 ratio existed, were closest to such even distribution (Fig. 6).

The intensity of setting differed considerably from year to year. It was lowest in 1957, when only about three oysters per 100 shells were counted at each station during the entire season; in 1939 and 1940 over 42,000 spat were counted under identical conditions (Fig. 7, Table II). A comparison of the numbers of oyster set at the stations of the three different depths showed that no one depth consistently produced the heaviest set (Table III).

Each group of stations, whether at the 10-, 20-, or 30-foot depth, occupied the first, second, or third rank during one or more years of our observations. If all stations, regardless of depth, were considered, then, as already mentioned, 1939 was the year of heaviest setting, and 1957 was the poorest. Stations of different depths differed in this respect, however. For example, in 1939 the stations at the 30-foot depth had the heaviest set of the entire 25-year period (Table IV). For the 10-foot stations, however, 1939 ranked third, and for the 20-foot stations it ranked second.

In some other years the differences in intensity of setting at stations of different depths varied even more. Thus, 1944 was the best year for the stations at 10-foot depth, but for 20-foot stations it ranked 13th and for the 30-foot stations, 8th. For all the stations taken together regardless of their depth it ranked the 5th heaviest year in 25. In some years, nevertheless, as in 1943, the annual rank-order was the same at three different depths (Table IV).

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Summary

1. Studies on setting of oysters in Long Island Sound during a 25-year period, 1937–61, have shown that the larvae of advanced stages were never extremely common and were unevenly distributed in the water masses. Their appearance and disappearance did not follow a definite pattern.

2. No clear relation was found between the number of certain larval enemies, such as ctenophores, and intensity of setting. Neither could the numbers of larvae be correlated with the numbers of adult oysters.

3. Dead or dying larvae were sometimes found in plankton. Disappearance of the larvae possibly may be due to the plankton blooms that produce detrimental external metabolites. A dinoflagellate, *Prorocentrum triangulatum,* on occasion present in extremely large numbers, may be one of the forms responsible for the absence of larvae during certain periods.

4. Setting of oyster larvae was recorded at all depths from the intertidal zone to 100 feet.

5. Beginning of setting at all stations at the depth of 30 feet or less normally occurred within the same 24-hour period.

6. The average length of setting season of oysters in Long Island Sound was 65 days. The shortest season was 36 days, and the longest was 85 days.

7. Setting in different years started between July 9 and August 11; the mean date was about July 20. The earliest end of setting was August 26, and the latest, October 17.

8. The setting in Long Island Sound is not continuous or of uniform intensity. Setting ceased almost every year for various periods, sometimes several weeks long.

9. Setting exhibited two well-defined waves in most years; each peak had a clearly evident maximum. The time these peaks appeared varied considerably from year to year. The time between the peaks of two waves in different years ranged from 19 to 40 days.

10. Neither the first nor second wave of setting was consistently predominant. Within the 25-year period the first wave was the heavier in 15 years, and the second in 10.

11. The intensity of setting in the same areas of Long Island Sound differed widely from year to year. Setting was lowest in 1957, when approximately three recently set oysters per 100 shell-surfaces were counted at each station during the entire season; in 1939 and 1940 over 42,000 spat were counted under the same conditions.

12. Comparison of the numbers of oyster set at stations of three depths—10-, 20-, and 30-feet—showed that no depth consistently produced the heaviest set. Stations of each of the three depths had the greatest abundance of larvae during one or more years of the period of observations.

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